ECL Comfort 200/300 and ECL 2000 HVAC LonWorks®

Table of Contents

1. Overview

Introduction 5
About this manual 5
Assumptions 5
What you should already know 5
LonWorks overview 6
The Lon (Local Operating Network) Concept 6
Applications 6
Node arrangements 7
Message Passing 7
Collision dectection 8
Network Management 8
Routers and bridges 9
ECL LonWorks node 10

2. Free Topology Network Configuration

Singly terminated bus loop 11
Doubly terminated bus loop 11
Star topology 11
Loop topology 11
Mixed topology 11

3. Free Topology Wiring

System performance and cable selection 12
Cable parameters 12
System specifications 12
Transmission specifications 13
Doubly-terminated bus topology specifications 13
Free topology specifications 13

4. Twisted Pair Network Configuration

Doubly terminated bus topology 13

5. Transformer-Coupled Twisted Pair Wiring

Performance specification 14
Communication on TP/XF-78 and TP/XF-1250 channels 14

6. Cable Specifications

Level 4 cable 15
Cable suppliers 16

7. Service Switch

Service Switch ECL Comfort 200/300 17
Service Switch ECL 2000 17

8. Interface / Network Variables

Interoperability 18
ECL control

1. Overview

Introduction

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The documentation in this manual is intended to provide you with comprehensive information on how to install and set up your LonWorks Option Card for communication over a LonWorks communication network.

For more specific information on installation and operation of the ECL please refer to the User Manual and Installation Guide.

About this manual

This manual is intended to be used both as an instructional and a reference manual. It only briefly touches on the basics of the LonWorks protocol whenever it is necessary for gaining an understanding of the LonWorks Option module for the Danfoss ECL Comfort 200/300 and Danfoss ECL 2000.

This manual is also intended to serve as a guideline when you specify and optimize your communication system. The list of contents is also a decision route that will guide you through the decisions you have to make before you set up your system.

Please refer to the manuals:
Technical Manual ECL 2000 LON Option and LONWorks in ECL Comfort for detaield and technical information.

Even if you are an experienced LonWorks programmer, we suggest that you read this manual in its entirety before you start programming, since important information can be found in all sections.

Assumptions

This manual assumes that you are using a LonWorks Option Card in conjunction with a Danfoss ECL Comfort 200/300 or ECL 2000. It is also assumed that you have a controller node that supports the interfaces in this document and that all the requirements stipulated in the controller node as well as the ECL Comfort 200/300 or ECL 2000 are strictly observed as well as all limitations therein.

What you should already know

The Danfoss LonWorks Option Card is designed to communicate with any controller node that supports the interfaces defined in this document.

It is assumed that you have full knowledge of the capabilities and limitations of the controller node.

LonWorks Overview

LonWorks is both an existing standard and physical hardware developed by Echelon Corporation.

Echelon's stated goal is to establish a commodity solution to the presently daunting problems of designing and building control networks.

Customers are currently using LonWorks for process control, building automation, engine control, elevator control, life safety systems, power distribution controls and similar intelligent building applications.

The Lon (Local Operating Network) Concept

The LonWorks communications structure is similar to that of a LAN in that messages are exchanged between a number of processors continually. LonWorks control devices are called nodes. The LonWorks systems are determined Local Operating Network, or LON. LON technology offers a means for implementing distributed systems that perform sensing, monitoring, control, and other applications.

LON allows intelligent devices, such as actuators and sensors, to communicate with one another through an assortment of communications media using a standard protocol. LON technology supports distributed, peer-to-peer communications. That is, individual network devices can communicate directly with one another, and a central control system is not required. LON is designed to move sense and control messages which are typically very short and which contain commands and status information that trigger actions. LON performance is viewed in terms of transactions completed per second and response time. The critical factor in LON technology is the assurance of correct signal transmission and verification. Control systems do not need vast amounts of data, but they do demand that the messages they send and receive are absolutely correct.

Applications

A key benefit of LonWorks networks is their ability to communicate across different types of transmission media in a single system. The NEURON chip's (the NEURON chip is the heart of the LonWorks system) communication port allows for the use of transceivers for other media (e.g. coax, fiber optic, etc.) to meet special needs.

With the proper design, the nodes become generic building blocks that can be applied in various ways to control lighting (or any other task) in many different buildings using a variety of communications media. The tasks which the nodes perform in any given situation are determined by how they have been connected and configured. Because hardware design, software design, and network design are all independent in a LonWorks-based system, a node's function can be programmed without concern about the specifics of the networks in which they will be used.

Physically, each node will consist of a NEURON chip and a transceiver.

Node Arrangements

LonWorks nodes can be addressed either individually or in groups. A group can contain up to 64 nodes, and one LonWorks network can support up to 255 groups. Furthermore, any node can be part of up to 15 different groups. A subnet is very similar to a group, but can contain up to 127 nodes. A domain is the largest grouping of nodes. A single domain can handle up to 255 subnets. Thus a single domain can handle up to 32,385 separate nodes. A single node may be connected to no more than two domains.

The group structure has the advantage of allowing a number of nodes to be reached at only one address. This method keeps the record keeping inside each chip to a minimum, and allows for faster operating times. However, individual addressing can be done at all levels of a LonWorks system, with high efficiency. The address table of a node contains entries for the group type and size, and tells the node how many acknowledgments to expect when it sends a message. It also tells the NEURON chip which domain (the largest possible grouping of nodes) to use, what this node's group member number is, (to identify an acknowledgment as coming from this node), and contains a transmit timer, a repeat timer, a retry count, a receive timer, and the group ID.

Message Passing

There are a number of trade-offs between network efficiency, response time, security, and reliability. Generally, LonWorks defaults to the greatest degree of safety and verification for all communications over the LON network. The LonTalk protocol (the operating system that coordinates the LonWorks system and is built into the chips) offers four basic types of message service:

The most reliable service is "acknowledged," or end-to-end acknowledged service, where a message is sent to a node or group of nodes and individual acknowledgments are expected from each receiver. If an acknowledgment is not received from all destinations, the sender times out and re-tries the transaction. The number of retries and time-out are both selectable. Acknowledgments are generated by the network CPU without intervention of the application. Transaction IDs are used to keep track of messages and acknowledgments so that the application does not receive duplicate messages.

An equally reliable service is "request/response," where a message is sent to a node or group of nodes and individual responses are expected from each receiver. Incoming messages are processed by the application on the receiving side before a response is generated. The same retry and time-out options are available as with acknowledged service. Responses may include data, so that this service is particularly suitable for remote procedure call, or client/server applications.

The next most reliable service is "unacknowledged repeated," where a message is sent to a node or a group of nodes multiple times, and no response is expected. This service is typically used when broadcasting to large groups of nodes and when traffic generated by all the responses would overload the network.

The least reliable method is "unacknowledged," where a message is sent once to a node or group of nodes and no response is expected. This option is typically used when the highest performance is required, network bandwidth is limited, and the application is not sensitive to the loss of a message.

Collision Detection

The LonTalk protocol uses a unique collision avoidance algorithm (a special mathematical equation) which allows an overloaded channel to carry close to its maximum capacity, rather than have its throughput reduced due to excessive collisions between messages. (Collisions are analogous to 10 people trying to talk all at once on a single telephone line. The messages are garbled and confused, and the contents of the messages are lost.) When using a communications medium that supports collision detection (twisted pair, for example), the LonTalk protocol can optionally cancel transmission of a packet as soon as a collision is detected by the transceiver. This option allows the node to immediately retransmit any packet that has been damaged by a collision. Without collision detection, the node would have to wait the duration of the retry time to notice that no acknowledgment was received, at which time it would retransmit the packet, assuming knowledge or request/response service. For unacknowledged service, an undetected collision means that the packet is not received and no retry is attempted.

Network Management

Depending on the level of a given application, a LonWorks network may or may not require the use of a Network Management node. A Network Management node is a node that has been specifically designated to perform network management functions, such as:

- Find unconfigured nodes and download their network addresses.
- Stop, start, and reset node applications.
- Access node communication statistics.
- Configure routers and bridges.
- Download new applications programs.
- Extract the topology of a running network.

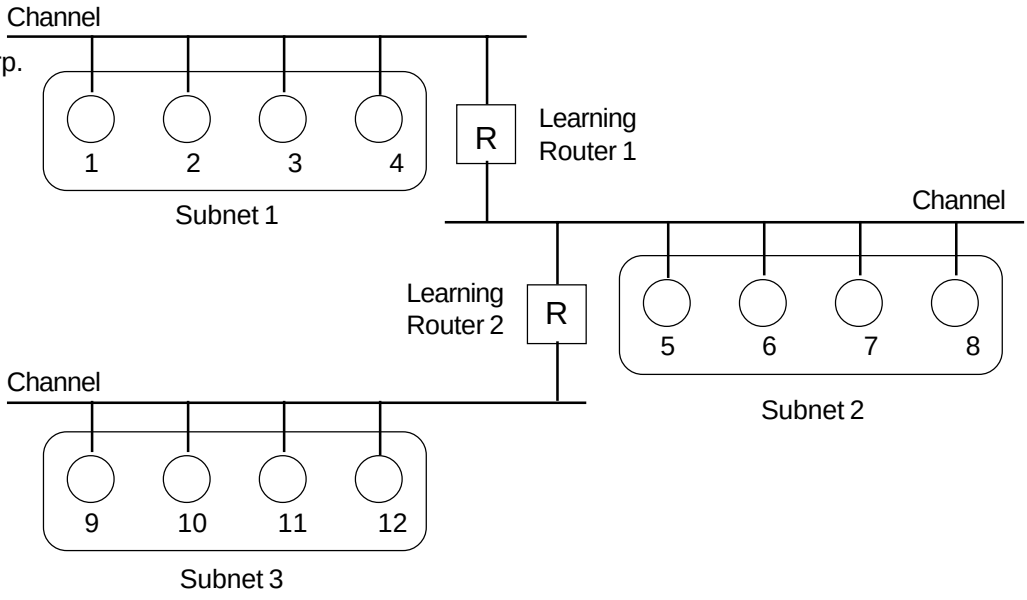
Routers and Bridges

A router (or bridge) is a special node that consists of two connected NEURON chips, each connected to a separate channel, see figure. Routers and bridges pass packets back and forth between these channels. There are four types of routers: A repeater is the simplest form of router, simply forwarding all packets between the two channels. Using a repeater, a subnet can exist across multiple channels. A bridge simply forwards all packets which match its domains between the two channels. Using a bridge, a subnet can exist across multiple channels. Like a learning router, a configured router selectively routes packets between channels by consulting internal routing tables. Unlike a learning router, the contents of the internal routing tables are specified using Network Management commands. A learning router monitors the network traffic and learns the network topology at the domain/subnet level. The learning router then uses its knowledge to selectively route packets between channels.

Initially, each router sets its internal routing tables to indicate that all subnets could lie on either side of the router. Referring to figure, suppose that node 6 generates a message bound for node 2. Learning router 1 initially picks up the message. Examining the source subnet field of the message, the learning router notes in its internal routing tables that subnet 2 lies below it. The router then compares the source and destination subnet IDs and since they are different, the message is passed on. Meanwhile, learning router 2 has also passed the message on, making an appropriate notation in its internal routing tables regarding the location of subnet 2.

Suppose now that node 2 generates an acknowledgment. This acknowledgment is picked up by learning router 1, which now notes the location of subnet 1. Learning router 1 examines its internal routing tables, and noting that subnet 2 lies below, passes the message on. When the message appears on subnet 2, it is noted by both node 6 (the destination node), and learning router 2, which does not pass it on but merely notes that subnet 1, like subnet 2, lies somewhere above. Learning router 2 will not learn of the existence or location of subnet 3 until a message is originated from there. Subnets cannot cross routers. While bridges and repeaters allow subnets to span multiple channels, the two sides of a router must belong to separate subnets. The fact that routers are selective about the packets they forward to each channel can be used to increase the total capacity of a system in terms of nodes and connections.

Learning Routers
Source: Echelon Corp.



ECL LonWorks Node

The ECL LonWorks option will perform as an integrated part of the ECL Comfort 200/300 and ECL 2000. The ECL LonWorks option will provide unmatched control and flexibility of the ECL Comfort 200/300 and ECL 2000 over a variety of LonWorks Networks.

Addressing nodes on the LonWorks network is performed at installation time by an installation tool or network management tool. Addressing requires the retrieval of a node's Neuron ID. The Neuron ID is a 48 bit number that uniquely identifies every manufactured Neuron chip. The ECL LonWorks option supports the three methods of addressing a node:

1. Query and Wink - The LonWorks option card is shipped with a predefined domain and subnet. Upon receiving the wink command, the ECL Comfort 200/300 and ECL 2000 will flash the total display so the installer can locate the node.

2. Service Pin - When the service Pin is activated via keys on the front, the ECL LonWorks option will send out it's Neuron ID over the network.

Binding is the installation time process of logically connecting one node's output network variable to another node's input network variable. To support binding, the ECL LonWorks option includes the node's interface file (XIF). The ECL LonWorks option does not transmit network variables over the network which are not binded so there will be no added overhead on the network.

LonWorks supports many different types of transmission media. A LonWorks network physical layer can be: transformer coupled twisted pair (78 kbps and 1.25 Mbps), free topology, link power, power line, RF, RS-485, fiber optic, coaxial, and infrared.

The ECL LonWorks option supports two transmission media with the versions of the ECL LonWorks option card:

ECL Comfort and ECL 2000

1. Free topology (FTT-10-A). The free topology node will also operate on a link power network.

ECL 2000

2. 78 kpbs transformer coupled twisted paid (TP/XF-78).

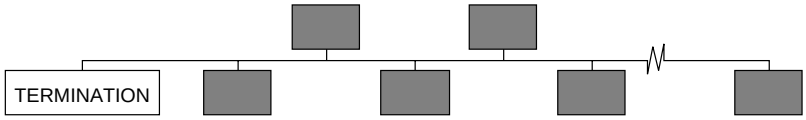
A router is required to interface to a LonWorks network that is not supported by the option card versions.

2. Free Topology Network Configuration

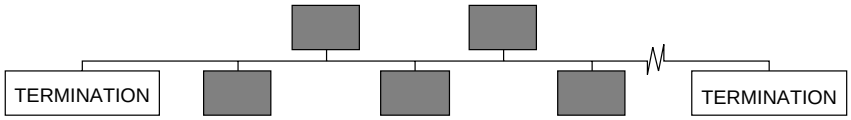
The FTT system is designed to support free topology wiring, and will accommodate bus, star, loop or any combination of these topologies. FTT-10 transceivers can be located at any point along the network wiring.

High capability simplifies system installation and makes it easy to add nodes should the system need to be expanded. The figures present five different network topologies.

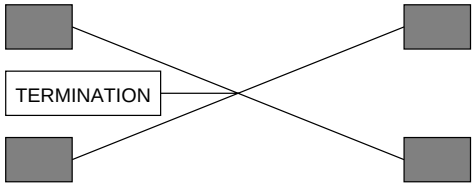
Singly Terminated Bus Loop



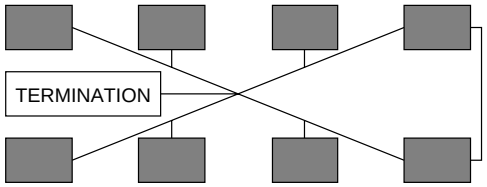
Doubly Terminated Bus Loop



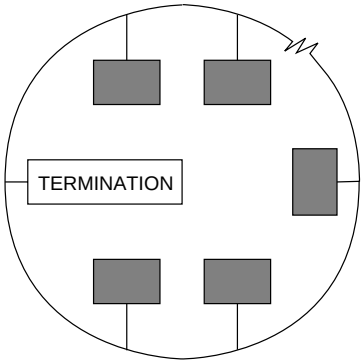
Star Topology



Loop Topology



Mixed Topology



3. Free Topology Wiring

System Performance and Cable Selection

FTT-10 system and transmission specifications are outlined on the following pages. Both of these specifications should be met to ensure proper operation.

The system designer may choose a variety of cables, depending on cost, availability, and performance. Performance may vary with cable type.

The transmission specification depends on such factors as resistance, mutual capacitance, and the velocity of propagation.

Echelon will characterize system performance on the following cable types. Electrical parameters shown in the table are typical.

Cable Parameters

Cable Type	Wire dia./AWG	Rloop ý/km	C nF.km	Vprop % of c
Belden 85102, single twisted pair, stranded 9/29, unshielded, plenum	1.3mm/16	28	56	62
Belden 8471, single twisted pair, stranded 9/29, unshielded, non-plenum	1.3mm/16	28	72	55
Level IV 22AWG, twisted pair, typically solid & unshielded	0.65mm/22	106	49	67
JY (St) Y 2x2x0.8, 4-wire helical twist, solid shielded	0.8 mm/20.4	73	98	41

Note that the following specifications are for one network segment. Multiple segments may be combined using repeaters to increase the number of nodes and distance.

System Specifications

- Up to 64 FTT-10 transceivers, or 128 LPT-10 transceivers are allowed per network segment.
- The average temperature of the wire must not exceed +55°C, although individual segments of wire may be as hot as +85°C.
- Both types of transceivers may be used on a given segment, provided that the following constraint is met: (2 x number of FTT-10 transceivers) + (1 x number of LPT-10 transceivers) - 128

Transmission Specifications

Free Topology nodes run at 78kbps transmission speeds.

Doubly-Terminated Bus Topology Specifications

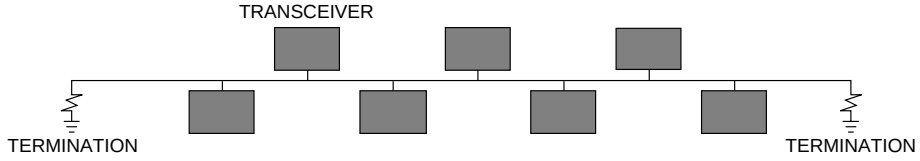
	Maximum bus length for segments with FTT-10 tranceivers only	Maximum bus length for segments with both FTT-10 and LPT-10 transceivers	Units
Belden 85102	2700	2200	meters
Belden 8471	2700	2200	
Level IV, 22AWG	1400	1150	
JY (St) Y 2x2x0.8	900	750	

Free Topology Specifications

	Maximum node-to-node distance	Maximum total wire length	Units
Belden 85102	500	500	meters
Belden 8471	400	500	
LeveleIV, 22AWG	400	500	
JY (St) Y 2x2x0.8	320	500	

4. Twisted Pair Network Configuration

Doubly Terminated Bus Topology



5. Transformer-Coupled Twisted Pair Wiring

Performance Specification

The table provides a summary of the performance specifications for the 78 kbps and 1.25 Mbps transformer-coupled twisted pair channels.

Communication on TP/XF-78 and TP/XF-1250 channels;

Performance Specifications	TP/XF-78 - Only supported by ECL 2000	TP/XF-1250 - Not supported by any ECL's
Transmission Speed	78kbps	1.25Mbps
Nodes per Channel	64 (0 to +70°C)	64 (0 to +70°C)
Network Bus Wiring	UL Level IV, 22 AWG (0.65 mm) twisted pair	
Network Stub Wiring	UL Level IV, 22 or 24 AWG (0.5 mm) twisted pair	
Network Bus Length Typical [1] Worst case [2]	 2000m 1330m	 500m 125m
Maximum Stub Length [3]	3m	0.3m (0 to 70°C)
Network Terminators	Required at both ends of the network	
Temperature Operating Non-operating	 0 to +70°C (64 node load) –40 to +85°C (44 node load)	 0 to +70°C (64 node load) –20 to +85°C (32 node load) –40 to +70°C (20 node load)
Electrostatic Discharge to Network Connectors No Errors No Hard Failures	 to 15,000V to 20,000V	 to 15,000V to 20,000V
Isolation between Network and I/O Connectors 0 - 60Hz (60 seconds) 0 - 60Hz (continuous)	 1,000 VRMS 277 VRMS	 1,000 VRMS 277 VRMS

1 Typical conditions are 20°C, +5VDC supply voltage, normal wire temperature, and 64 evenly distributed nodes.

2 Worst case conditions are the combined effect of worst case conditions of all the above performance parameters — nodes per channel, network bus length, stub length, temperature, etc.

3 The stub length in the table assumes a mutual capacitance of 17 pF/ft (56 pF/m) for the twisted pair stub cable. Actual lengths may be shorter or longer depending on the actual, measured value.

NOTE:
It is necessary to terminate the ends of a TP/XF-78 or TP/XF-1250 twisted pair bus to minimize refelections. Failure to terminate the bus will degrade network performance.

6. Cable Specifications

Level 4 Cable Specifications

The Level 4 cable specification used by Echelon and as originally defined by the National Electrical Manufacturers Association of the USA (NEMA) differs from the Category IV specification proposed by the Electronic Industries Association/Telecommunication Industry Association (EIA/TIA). The Level 4 cable specifications used by Echelon are presented below, and are followed by a list of Level 4 cable suppliers.

Specifications apply to shielded or unshielded 22AWG (0.65mm) cable 24AWG (0.5mm) cable shown in brackets [ ] if different	
DC Resistance (Ohms/1000 feet at 20°C) maximum for a single copper conductor regardless of whether it is solid or stranded and is or is not metal-coated.	18.0 [28.6]
DC Resistance Unbalance (percent) maximum	5
Mutual Capacitance of a Pair (pF/foot) maximum	17
Pair-to-Ground Capacitance Unbalance (pF/1000 feet) maximum	1000
Impedance (Ohms)	
772kHz	102 ±15% (87-117)
1.0MHz	100 ±15% (85-115)
4.0MHz	100 ±15% (85-115)
8.0MHz	100 ±15% (85-115)
10.0MHz	100 ±15% (85-115)
16.0MHz	100 ±15% (85-115)
20.0MHz	100 ±15% (85-115)
Attenuation (dB/1000 feet at 20°C) maximum	
772kHz	4.5 [5.7]
1.0MHz	5.5 [6.5]
4.0MHz	11.0 [13.0]
8.0MHz	15.0 [19.0]
10.0MHz	17.0 [22.0]
16.0MHz	22.0 [27.0]
20.0MHz	24.0 [31.0]
Worst-Pair Near-End Crosstalk (dB) minimum. Values are shown for information only. The minimum next coupling loss for any pair combination at room temperature is to be greater than the value determined using the formula NEXT (F_{MHz}) > NEXT (0.772) – 15_{log10} (F_{MHz}/0.772) for all frequencies in the range of 0.772MHz – 20MHz for a length of 1000 feet	
772kHz	58
1.0MHz	56
4.0MHz	47
8.0MHz	42
10.0MHz	41
16.0MHz	38
20.0MHz	36

Level 4 Cable Suppliers

Anixter
4711 Golf Road
Skokie, IL 60076

Ph: 708-677-2600
FAX: 708-677-2668

Anixter stocks the following cables which they will cut to size.

Part No.	Description
9D220150	22 AWG (0.65mm) / 1 pair solid, unshielded, PVC
9F220150	22 AWG (0.65mm) / 1 pair solid, shielded, PVC
9D220250	22 AWG (0.65mm) / 2 pair solid, unshielded, PVC
9F220254	22 AWG (0.65mm) / 2 pair solid, shielded, PVC
9H2201504	22 AWG (0.65mm) / 1 pair solid, unshielded, plenum
9J2201544	22 AWG (0.65mm) / 1 pair solid, shielded, plenum
9H2202504	22 AWG (0.65mm) / 2 pair solid, unshielded, plenum
9J2202544	22 AWG (0.65mm) / 2 pair solid, shielded, plenum

Connect-Air
International, Inc.
50-37th Street N.E.
Auburn, WA 98002

Ph: 206-813-5599
FAX: 206-813-5699

The following table lists cables stocked by Connect-Air.

Part No.	Description
W221P-1002	22 AWG (0.65mm) / 1 pair strand, unshielded, PVC
W222P-1004	22 AWG (0.65mm) / 2 pair strand, unshielded, PVC
W221P-1003	22 AWG (0.65mm) / 1 pair strand, shielded, PVC
W222P-1005	22 AWG (0.65mm) / 2 pair strand, shielded, PVC
W221P-2001	22 AWG (0.65mm) / 1 pair strand, unshielded, plenum
W221P-2003	22 AWG (0.65mm) / 2 pair strand, unshielded, plenum
W221P-2002	22 AWG (0.65mm) / 1 pair strand, shielded, plenum
W222P-2004	22 AWG (0.65mm) / 2 pair strand, shielded, plenum

Link Power/ Free Topology Cable Suppliers

Level 4 22AWG (0.65mm) cables may also be used.

Belden
P.O. Box 1980
Richmond, IN 47375

Ph: 206-813-5599

Part No.	Description
8471	16 AWG (1.3mm) / 1 pair strand, unshielded, PVC
85102	16 AWG (1.3mm) / 1 pair strand, unshielded, plenum

7. Service Switch

Service Switch ECL Comfort 200/300

When starting up the LON option, a period of about 30 seconds will elapse during which the database from the regulator will be entered. During this starting-up period it is not possible to come into contact with the LON option, neither from ECL Comfort nor from the network. The starting-up period will occur on reset/power up regulator/LON option and when an application change is made in ECL Comfort.

After starting up, the following parameters can be activated via the ECL Comfort MMI interface:

Parameter 196 in circuit 1 is the service pin.

Parameter 197 in circuit 1 is the LON option reset.

Parameter 196 and 197 can be accessed by scrolling down through the parameters on the installer page (grey page) with the arrow keys. The parameters can be activated/deactivated with the +/- keys (see instructions).

At wink, the display will flash until any key is pressed on ECL Comfort.

When updating parameters in ECL Comfort the values must lie in a workable range. If they fall outside the range they will be rejected.

Service Switch ECL 2000

When the service pin of the LON device is activated, the device broadcasts its Neuron ID onto the network. To activate the ECL 2000's service pin:

1. In the System Overview picture, press to access the CommonFunctions service menu.
2. Press until **Communication** is selected.
3. Press to access the Communication picture shown to the left.
4. Press to activate the service pin.

Depending on the setup of the ECL 2000, you may be required to enter an access code before the service pin can be activated. See the ECL 2000 User's Guide (ref. [1]) for instructions on entering the access code.

8. Interface / Network Variables

Interoperability

Interoperability refers to the ability of independent nodes to operate together over the LonWorks network. The LonMark program was developed to address interoperability issues. The Lonworks option supports the following LonMark activities to improve interoperability:

1. Standard Network Variable Types (SNVT's); SNVT's define the units, limits and resolution of network variables so that nodes have a common platform for representing data items. The LonWorks option only uses SNVT's to transmit and receive data over the LonWorks network.

2. Standard Objects;
   Standard Objects are a collection of SNVT's to perform a function. The LonWorks option supports the node object and a controller standard object as defined in the LonMark Interoperability guidelines 2.0.

3. LonMark Interoperability Association Tast Groups (LonUsers Groups); Tast groups define SNVT's and standard objects to create standards and models to be used by particular applications. Danfoss is active in defining standards for LonUser groups.

ECL Control

The ECL LonWorks option supports all SNVT's for flexible control of the ECL over the LonWorks network.

Please refer to the manuals:
Technical Manual ECL 2000 LON Option and LONWorks in ECL Comfort for detaield and technical information.

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